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TITLE: Operator-Machine Interface at a Large Laser-Fusion Facility

AUTHOR(S): J. G. Sutton
J. A. Howell

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MASTER

Los Alamos Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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Large Laser Fusion Facility

J. G. Sutton
J. A. Howell
Group P-11
Mail Stop E532
Los Alamos National Laboratory
Los Alamos, NM 87545
505-667-6087

Abstract.

The Operator-Machine Interface at the Antares Laser Facility provides the operator with a means of controlling the laser system and obtaining operational and performance information. The goal of this Interface is to provide an operator with access to the control system in a comfortable way, and to facilitate meeting operational requirements.

We describe the philosophy and requirements behind this Interface, the hardware used in building it, and the software environment.

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I. INTRODUCTION

The Antares Laser Facility is the world's largest carbon dioxide laser (Ref. 4). This 40-kilojoule laser was designed to study inertial confinement fusion processes using carbon dioxide lasers. We have designed and built an Operator-Machine Interface at this facility in order to provide the operator with a means of controlling the laser system and obtaining operational and performance data. The goal of this Interface is to provide an operator with access to the control system in a manner which is comfortable, and to facilitate meeting operational requirements. We have achieved this goal by providing the operator with an interacive color graphics system which is "user-friendly", that is, it provides good response, good prompts, feedback, and good recovery capability (Ref. 2). We have used the senses of sight, color, touch, and sound.

The Antares project has approximately 160 people working on the laser system of which about 35 are assigned to the control system. Of the control system personnel 10 are involved in the software effort. Three people are now working on the Operator-Machine Interface.

II. THE CONTROL SYSTEM

The control system for which the Operator-Machine Interface was built is responsible for operations such as the pulse power system required to pump the carbon dioxide laser, the alignment of the optical transport system, and the facility safety system. It is also responsible for the acquisition of data from the electrical and laser diagnostics systems. These systems are operated in several modes: checkout and maintenance, stand-alone sub-system automatic operation, and integrated automatic operation (Ref. 1).

The control system will eventually control and accept data from approximately 3100 channels. It will acquire, store, and display approximately 200,000 bytes of information per laser firing and control about 119 interacting processes. It must perform these tasks in an environment of severe electromagnetic interference generated by the laser.

The control system consists of one Digital Equipment Corporation (DEC) PDP-11/70, four DEC PDP-11/60's, one DEC PDP-11/34, and several dozen DEC LSI-11s. The larger machines use the UNIX operating system (Ref. 5), and the LSI-11's use a stand-alone manager written locally. All of the control system computers are connected in a locally written network. Operator-Machine Interface terminals are provided at the locations shown on the Antares Control System Implementation diagram (Figure 1) where the stick figures are shown.

III. THE INTERFACE PHILOSOPHY

The major requirement is to provide a comfortable and friendly Operator-Machine Interface. The operator should feel that he or she is a part of the laser system and in control of the events that are taking place. More precisely, the Interface should have a quick and accurate response to operator requests, and should provide a complete and easy to assimilate view of the laser system performance. The Interface should perform in a smooth and predictable manner, and not cause any surprises. It should be consistent and easy to learn. The operator should not be paced by the system nor be required to do unnecessary tasks.

In order to satisfy these requirements, we have adopted and documented a collection of philosophies, standards, hardware, software, and utilities. The hardware, software, and utilities are the tools of the Interface, and the philosophies and standards form the guidelines for the proper use of those tools.

These philosophies and standards play a major role in determining the quality of the Operator-Machine Interface. They guide those designing a color terminal display for any particular subsystem at Antares. Among those items standardized are the symbols, colors, status representation style, and prompts to be used on displays.

The general approach is to use a touch panel on the display screen instead of a keyboard. A display containing buttons and/or schematic representations of components is presented to the operator. Buttons and components that are selectable are highlighted. To select some function, the operator touches an item on the screen. This results in some control system action or a new set of highlighted actions. By careful use of colors and actions, the operator is essentially led through a sequence of legal operations.

IV. THE INTERFACE HARDWARE

The hardware approach adopted is represented in Figure 2. The motivation for this configuration is mostly from the performance requirements placed on the Operator-Machine Interface. To be able to change displays in just a few seconds dictates that the display information not be sent over a 9600 baud serial link. A simple display file could have from 2000 to 3000 bytes of information, but a complex display could have as many as 10,000 bytes. At a transfer rate of less than 1000 bytes per second, this would require from 3 to over 10 seconds to erect a display on the screen. To solve this problem we have provided local (to the color terminal) disk storage for display information, and a parallel interface to the color terminal.

The LSI-11 series processors where chosen for the host processor since they are Antares standards. The LSI-11/23 was selected to be the supporting processor for its speed. The Data Systems Design DSD880 disk was selected through competitive bidding on a specification for a disk. It has a 7.8 megabytes capacity. The Advanced Electronics Design AED-512 was also selected through competitive bidding on a specification for a color graphics terminal. The Elographic Touch Panel was selected because it was the only touch panel on the market that had a resolution equivalent to the AED-512 color terminal. The touch panel's resolution is adjustable to 4096 x 4096, but is presently set to 512 x 512.

V. THE INTERFACE SOFTWARE

The software that supports the Operator-Machine Interface has been organized in the same manner as the software that supports the rest of the Antares Control System. This provides uniformity, facilitates implementation, and aids in maintenance.

Figure 3 shows the procedure followed by a display designer when building a color display for a particular part of the system. The designer might start with a sketch obtained from the project-engineer for the particular sub-system. Using the Antares Graphics Editor, the designer would construct the static display for the color terminal. The Antares Graphics Compiler is then used to translate the Graphics Editor output into a form that the Operator-Machine Interface software can use. This information along with similar information for all other displays is transferred to the local disk storage at the Operator-Machine Interface station. The designer then writes the software that obtains the dynamic data from the laser system and sends it to the Operator-Machine Interface station where it is placed on the static display (see Figure 4).

The Antares Operator-Machine Interface has been designed in a manner that provides a comfortable, easy to use interface (see Figure 5) for the Antares Operators as well as providing a modular system that is easy to change and/or enhance. Additions or changes to one part of the system can be made without affecting other parts of the system The Antares Operator-Machine Interface fits into the system hierarchy so that the ability to operate one part of the system when other parts are not operational is preserved.

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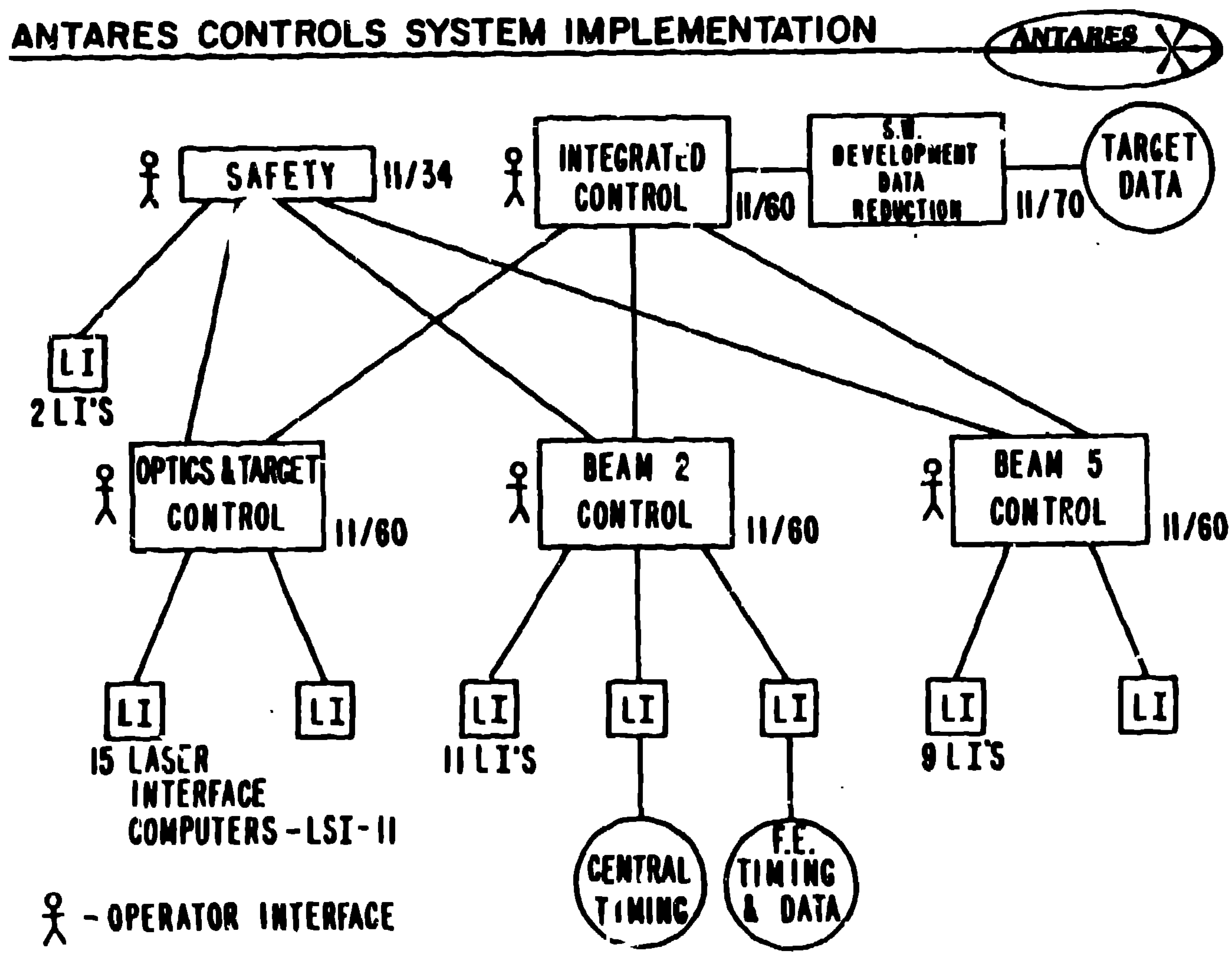
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INTEGRATED CONTROL
11/60
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11/70
TARGET DATA
LI
2 LI'S
OPTICS & TARGET CONTROL
11/60
BEAM 2 CONTROL
11/60
BEAM 5 CONTROL
11/60
LI
LI
15 LASER INTERFACE COMPUTERS - LSI-11
LI
LI
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11 LI'S
LI
LI
9 LI'S
CENTRAL TIMING
F.E. TIMING & DATA
- OPERATOR INTERFACE

Figure 1

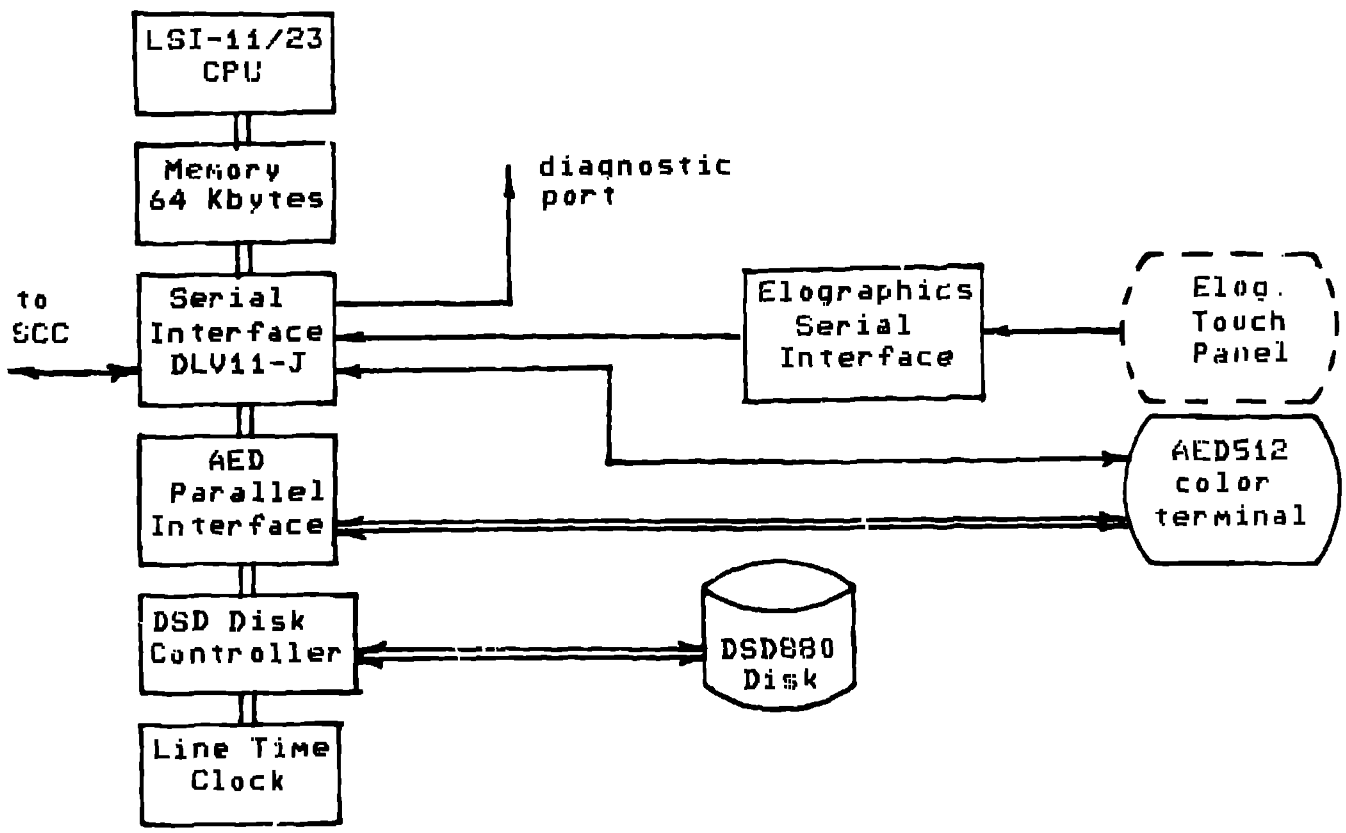

Figure 2

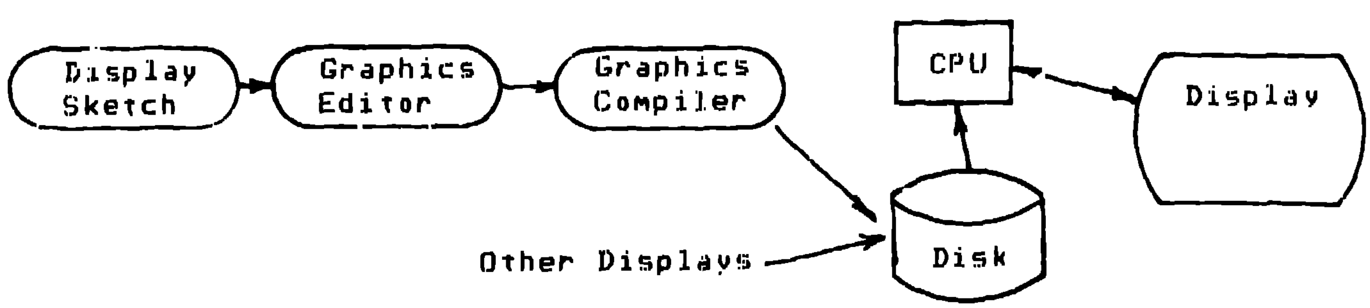

Figure 3

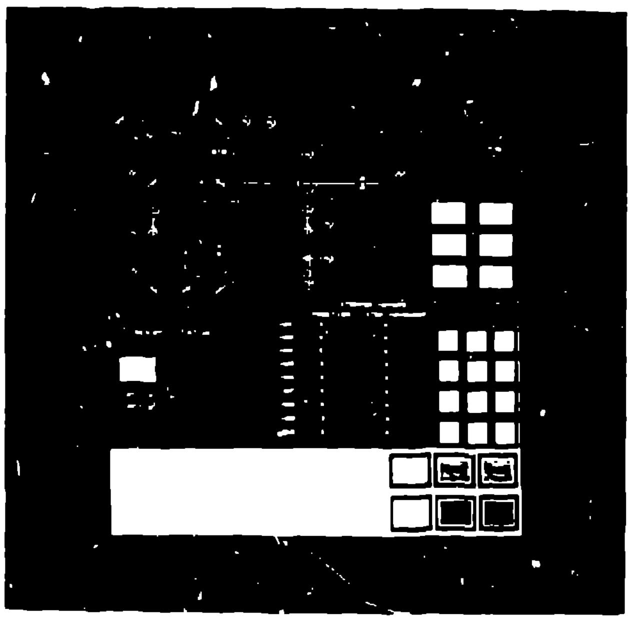

Figure 4

Figure 5